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Self-Healing Behaviour of Pre-Cracked POFA-Concretes under Curing Conditions

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Abstract

The investigation on the effect of curing conditions to self-healing of pre-cracked concrete containing palm oil fuel ash (POFA-concrete) are presented. POFA cement was replaced from 10%, 20% and 30% from the total weight of ordinary Portland cement (OPC). Four (4) types of curing condition namely air, room temperature, wet and dry, and water curing were carried out. The ultra-pulse velocity (UPV) test was performed to monitor the self-healing progress on POFA-concrete. The result shows 20% POFA-concrete recorded highest compressive strength compare to those mixes. It is also revealed the UPV readings were increased significantly with the increase curing ages. The results also obtained the self-healing ability of pre-cracked POFA-concrete at 10% replacement level increase significantly for water curing condition.

Introduction

It is predicted that the quantity of palm oil fuel ash (POFA), a profitless by-product generated by palm oil mill will be increased as the production of palm oil continue to grow over the year. POFA is a by-product produced in palm oil mill. Generally, after combustion process about 5% of POFA solid wastes are produced [6,7]. In practice, POFA produced in Malaysian palm oil mill is dumped as waste without any profitable return. In recent years, studies on using waste generated from the agricultural and industrial activities as partial replacement of cement concrete has been growth rapidly [8]. Many researchers have studied the use of agro-waste ashes as constituents in concrete. The findings revealed that this agro-waste ash contain high amount of silica in amorphous form and could be used as a pozzolanic material [7]. Previous researchers found that the pozzolanic activity indices of POFA is about 78.6% to 87.6% are more highest compare to those classes of the pozzolanic ash is about 75% (ASTM C 618-94a) [2, 9]. Abdul Awal and Hussin [3] have proved that this waste could be used as partial cement replacement in concrete for production of stronger and more durable construction material.

Methodology

- **Materials and Mix Proportion**

The control concrete mix was prepared using OPC while the POFA-concretes were prepared by replacing the cement part with POFA at 10%, 20% and 30% replacement levels. All series of concrete were designed for grade 30.

- **Test Procedures**

Compressive test: The compressive strength test of OPC-concrete and POFA-concretes was conducted after 7, 28, 60 and 90 days cured in water.

Pre-cracking test: Before the ultrasonic pulse velocity (UPV) test was performed, the remaining concrete specimens were cured in four (4) different types of curing. There are water curing, air curing, wet and dry curing and control room curing. Then, the specimens were taken out from the curing process to measure the initial readings using UPV. In order to monitor the progress on self-healing concrete activity, the specimens were subjected to compression load to perform the hairline crack (pre-cracking). The hairline cracks were measured using digital caliper under microscope to measure the hairline widths in ranges of 0.1 mm to 0.2 mm.

Result and Discussion

The results on compressive strength of the OPC-concretes and POFA-concretes are shown in Figure 1. It is revealed that POFA enhance the strength of concrete after 28 days immersed in water. It is also found that the compressive strength of POFA-concrete with 20% of replacement increase rapidly compared to those POFA-

concretes. This happen because the addition of 20% POFA is suitable as a cement replacement due to microfiller effect of POFA size.

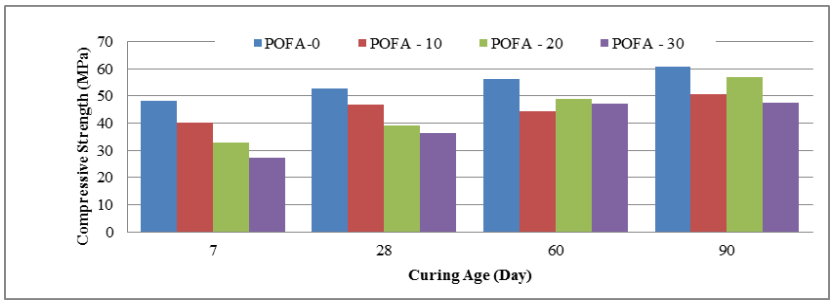

Figure 1: Compressive strength of OPC-concrete and POFA-concretes

The assessment on self-healing development for pre-cracked concrete using ultrasonic pulse velocity (UPV) were conducted after the specimens expose at 7 (pre-crack), 28, 60 and 90 days. The self-healing progress was measured by the increase of self-seal effect recorded by UPV before and after self-healing. It is found that in early stage, the hydration degree of POFA is small and mainly affected by curing condition effect. In the late, POFA hydrated to produce C-S-H gel and the self-healing of concrete increased. All the POFA mixes have the best conformance and the self-healing ability is best represented by the changes of concrete specimens before and after pre-cracked concrete. It is found that the mixing amount of POFA is 10% subjected to water curing condition, the self-healing ability of concrete is the much strongest compare to those concrete mixes in different curing conditions.

Conclusion

It is concluded that, the use of POFA at 20% replacement level in concrete recorded highest in compressive strength. It is also revealed the UPV readings increased significantly with the increase of curing ages for all curing conditions. It is proved that the progress of self-seal of pre-cracked POFA-concretes is affected by different curing conditions. In addition, the self-healing ability of pre-cracked POFA-concrete at 10% replacement level increases significantly for water curing condition.

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